CARIBBEAN FOOD CROPS SOCIETY

SERVING THE CARIBBEAN SINCE 1963

CARIBBEAN FOOD CROPS SOCIETY

41

Forty First
Annual Meeting 2005

GUADELOUPE

Vol. XXXXI - Number 2

Proceedings of the Caribbean Food Crops Society. 41(2): 430-435. 2005

RELATIONSHIP BETWEEN SWEET POTATO PHYSICAL PROPERTIES AND VOLATILES RELEASE DURING BAKING

J.A. Dumas, C.E. Ortiz and S. M. Soler, Agricultural Experiment Station, University of Puerto Rico, Botanical Garden South, 1193 Guayacan Street, San Juan Puerto Rico 00926-1118 (e-mail: jose_dumas@cca.uprm.edu)

ABSTRACT. Improvement of selection criteria for breeding sweet potato in terms of flavor would be greatly facilitated by understanding its volatile composition. The aroma in the sweet potato comes from volatile compounds released by biochemical synthesis and chemical transformations during cooking. For ascertaining the chemical composition of the aroma, samples were baked in a closed system coupled to a cold solvent trap having dichloromethane. Aroma constituents were subsequently identified and quantified by using a gas chromatograph coupled to a quadruple mass spectrometer. Amounts of volatiles were compared with the flesh's physical properties and sugar content. Results suggest a straight relationship among some volatiles between them and in between some physical and chemical properties such as starch granule size and sugar content.

INTRODUCTION

Sweet potato (*Ipomoea batatas*) is an important root crop in the Caribbean Basin. Because of its versatility and adaptability, sweet potato ranks as the world's seventh most important food crop (FAO, 2000). Strong markets for fresh roots exist within the Caribbean Basin and in the Northeastern United States and Florida. In Puerto Rico, sweet potatoes production was the second crop in importance in 2004 with a total production of 64,473 t. Imports of 166,165 t were necessary to satisfy the local demand in the same year[2]. Most of these imports came from the Dominican Republic. Despite this fact, sweet potatoes popularity is declining (Sun et al., 1995). Reduced production throughout the Caribbean Basin can be explained in part by the lack of adapted varieties. For fresh market, sweet potato quality is defined in terms of attractiveness, taste and flavor after cooking. Flavor, composed of taste and aroma, is a primary trait utilized in the acceptance or rejection of food (Sun et al., 1995). The predominant taste is sweetness, due primarily to maltose and sucrose (Wang and Kays, 2000). However, the sucrose index alone cannot be used as a quantitative tool for sweetness in sweet potato, because the volatile and semi-volatile compounds may increase or decrease taste intensity in food (Wang and Kays, 2000). Qualitative and quantitative information regarding chemical and physical properties and their relationship with consumer preferences is scarce (Kays, 1985; Wu et al., 1991). Most of the research concerning taste and flavor in sweet potato has been performed in dessert types (orange-fleshed). The objective of this study was to characterize the volatile compounds present in four sweet potato varieties and to relate them to the physical and chemical properties of the root. Those results are part of a more ample effort to provide objective quantitative criteria for selection of sweet potato cultivars with good marketability characteristics which include sweetness, aroma and flavor.

[2] Preliminary data. Department of Agriculture. Statistic office.

MATERIALS AND METHODS

Field

Four sweet potato types were used in this study. Varieties within these types were Miguela, Martina, Viola and Ninetynine. Cultivars were planted in a randomized complete block design with four replicates at the Gurabo Substation located in the eastern central part of the main island of Puerto Rico. Harvest was performed at 150 days after planting. Roots weighing 400 to 500 g were selected at random from the field.

Sample Preparation:

With the procedures described by Hernandez-Carrion, sweet potato roots were tested for starch content and sugars (2001). The tuberous roots were cured by spreading the sample on a table for 7 days at room temperature. After curing, samples were processed raw and baked.

Sugar analysis:

Glucose, fructose, sucrose and maltose concentrations were determined by following a modification of the HPLC method described by Picha (Picha, 1985; Hernandez-Carrion, 2001). A liquid chromatograph system equipped with an autosampler and a refractive index detector was used. Glucose, fructose, sucrose and maltose were separated by using Prevail Carbohydrate ES analytical column (Alltech Co.). Mobile phase was 75:25 Acetonitrile: Water solution (1mL/min).

Volatile compound analysis:

A sweet potato flesh sub-sample was cut to approximately 1 cm^3 and 300 g was poured on a 1000 mL conical flask. The flask was capped and connected by Teflon pipes to a cold solvent trap. The flesh (Sweet potato pulp) was baked for 90 min at 120° C under a 40 mL/min nitrogen flow as volatile purging gas. The volatile constituents were trapped in 1 mL of cold dichloromethane (-20° C) spiked at 1 µg/mL of ethyl benzoate as internal standard. Samples were injected in Perkin Elmer Gas Chromatograph AutoSystem coupled to a TurboMass mass spectra detector. The analytical column was Supelcowax 60 m X 0.25 µm id (Supelco Co.) by using 1mL/min of helium as carrier gas.

Scanning Electron Microscopy (SEM)

Samples were dehydrated mounted on specimen stubs and sputter coated with a layer of gold by using a Pelco SC-7 Auto Spatter Coater and a Pelco FTV-2 Film Thickness monitor. A Jeol model JSM5800LV instrument was used for SEM determinations. Average size of starch granules was determined.

RESULTS AND DISCUSSION

Sweet potato taste is an interrelation of sugar content, odors, texture and flavors (Wang et al., 2000). It is well known that volatile compounds are one of the major factors involved in public acceptance of foods (Hau et al., 1996). The releasing of volatile compounds has been related to starch content; however, these compounds have not being related to more specific properties such as superficial area of starch granule and to sugar content. The purpose of this study was to gather information about volatile constituents from sweet potato varieties and to study their relationship to the physical structure of the flesh (pulp). Volatile constituents of four sweet potato types were isolated by dynamic headspace sampling of the baked pulp. Table 1 presents a summary of some volatiles found in the four sweet potato types studied. Volatile compounds belonging to chemical families such as alcohols, ketones, aldehydes, aromatic hydrocarbons, esters and terpenes were found. Ten volatile compounds were common for the four sweet potato types studied and some of them were chosen to compare the amounts trapped in cold dichloromethane to their physical and chemical properties presented in Table 2.

Table 1.Volatile Constituents of Baked Sweet Potato: Dynamic Headspace Sampling

	Sweet potato Type			
Compound	Ninetynine	Viola	Miguela	Martina
4-methyl-2-pentanone	X		X	
Hexanal	X	X	X	
4-methyl-3penten-2-one	X	X	X	
(E)-2-methyl-3-penten-2ol	X		X	
2-penten-4-ol	X	X	X	
Heptanal	X	X	X	X
3-methyl-1-butanol	X		X	
Benzaldehyde	X	X	X	X
2-pentylfuran	X	X	X	X
4-hidroxy-4-methyl-2-pentanone	X	X	X	X
2-butoxy ethanol	X	X	X	X
alpha copaene	X	X	X	X
Caryophellene	X	X	X	X
alpha gurjunene	X	X	X	X
alpha humulune	X	X	X	X
Isoledene	X	X	X	X

Sweet potato contains a variety of terpenes. The most abundant terpene was isoledene and probably is a major contributor to the odor. Other abundant terpenes were humulene, copaene and caryophellene. However, their odor threshold has not been determined until now and their contribution to odor has not been assessed. Terpenes amounts trapped in cold dichloromethane appear to be related to starch granule size (Fig 1). Among the four types of sweet potato studied, Viola had the largest starch granule size and sucrose index (Table 2). Viola also had the highest amount of terpenes released toward the headspace (Fig 1); some of them, such as isoledene, humulene, caryophillene and copaene showed a lineal relationship which pinpoints similar mechanisms of volatile releasing from pulp (Fig 2).

Table 2. Some Physical and Chemical Properties of Some Selected Sweet Potatoes.

Sweet potato Type	Sugar content				Sucrose index[a]	Starch size diameter (μm)
	Fructose %	Glucose %	Sucrose %	Maltose %		
Martina	0.14	0.77	3.72	2.65	5.29	12.9
Viola	0.18	0.58	4.31	7.80	7.36	25.2
Miguela	0.41	0.78	3.80	4.42	6.35	15.3
Ninetynine	0.22	0.68	3.60	0.95	4.72	16.9

[a]Sucrose index = 1.7*%fructose+1*%Sucrose+0.7*%Glucose+0.3*%Maltose

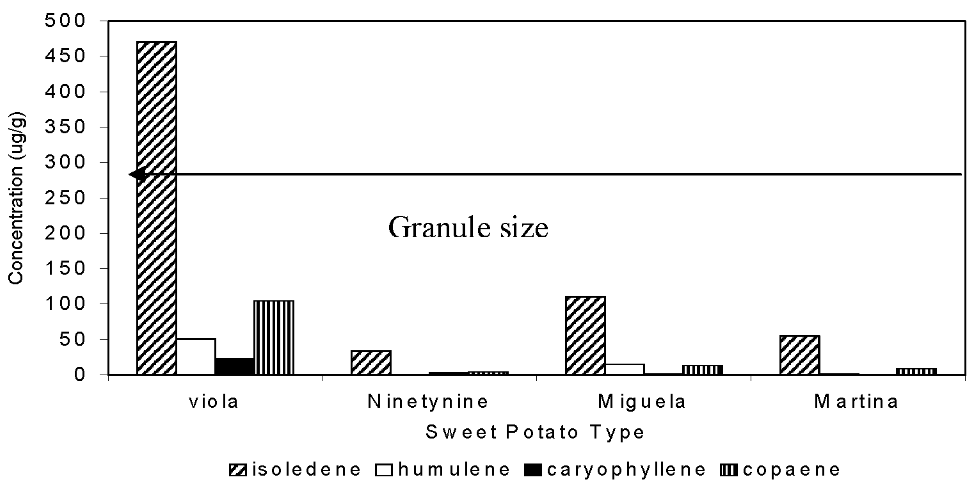

Figure 1. Relationship among terpenes concentration and sweet potato Type

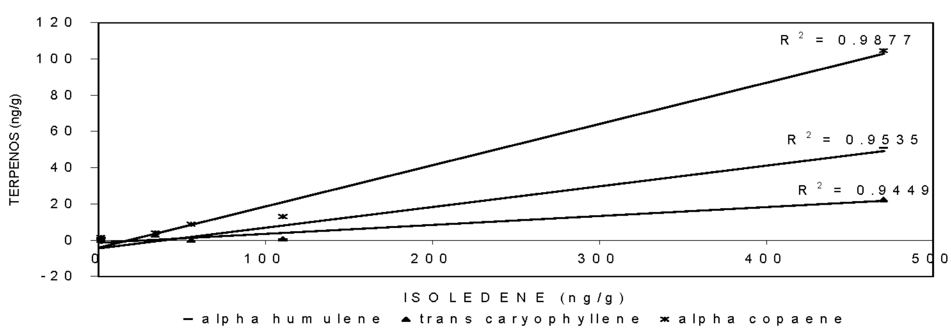

Figure 2. Relationship between terpenes released into headspace from sweet potato pulps

The reported ranking on perceptual sweetness for varieties studied is: Miguela > Martina > Viola > Ninetynine. Therefore, terpenes releasing is not related to perceptual sweetness or starch granule size or sucrose index. Moreover, the parameters mentioned above appear no to be good indicators of public preference among varieties.

The volatile compound 2-pentyl furan is probably a main aroma contributor in sweet potato as it is in 'Jewel' variety (Wang et al., 2000). This compound, along with benzaldehyde, 2-heptanal and hexanal was common for all sweet potato varieties studied. The concentrations of these compounds trapped in cold dichloromethane were lower for Miguela and Martina than for Viola and Ninetynine (Fig. 3).

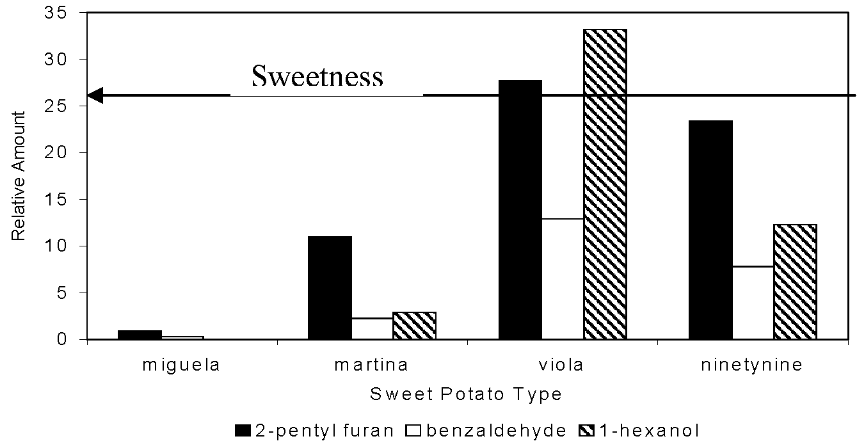

Figure 3. Amount of selected volatile compounds for sweet potato type.

As mentioned above Miguela and Martina tend to be more sweet to taste than are Viola and Ninetynine where sweetness appear to be related to lower amount of these compounds released during the baking process. However, care must to be taken when interpreting this information and further research investigation is needed.

ACKNOWLEDGMENTS

The financial support of the TSTAR program is greatly appreciated (Project Grant-431625). We thank to Tania Hernandez and Priscila Casanova for help in sample processing and analysis.

REFERENCES

FAO. 2000. FAO Statistical Databases FAOSTAT. Food and Agriculture Organization of the United Nations.

Hau M.Y.M., Gray D.A. & Taylor A. J. (1996) 'Binding of Volatiles to Starch' in Flavor-Food Interactions. Eds. McGorrin R.J. & Leland J.V. ACS symposium series 633, 109-117.

Hernandez-Carrion, T. 2001. Avalúo de azúcares y su variabilidad en batata [Ipomea batatas (L.) Lam.] tipo tropical. MS thesis. Agronomy and Soil Department. Univ of Puerto Rico University, Mayaguez Campus. Pp 113.

Kays, S.J. 1985a. Formulated sweetpotato products. En: J.C. Bouwkamp (ed.). Sweetpotato products: A natural resource of the tropics. pp. 205-218. CRC Press. Boca Raton, Florida

Picha, D.H. 1985. HPLC Determination of Sugars in Raw and Baked Sweet Potatoes. J. Food Sci. 50:1189-1190.

Sun, J-S., Severson, R.F., Schlotzhauer, W.S., Kays, S.J., 1995. Identifying critical volatiles in the flavor of baked "Jewel" sweetpotatoes. J. Amer. Soc. Hort Sci. 120: 468-474.

Wang, Y., S.J. Kays, 2000. Contribution of volatile compounds to the characteristic aroma of baked 'Jewel' sweetpotatoes. J. Amer. Soc. Hort. Sci. 125:638-643.
Wu, J.Q., S.J. Schwartz y D.E. Carroll. 1991. Chemical physical and sensory stabilities of prebaked frozen sweetpotatoes. Journal of Food Science 56:710-713.